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TAXONOMIC REVIEW OF THE  
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CONTRIBUTIONS TO THE JAPANESE ASCIDIAN FAUNA XXXII.  
TAXONOMIC REVIEW OF THE SPECIES GROUP OF  
*PYURA SACCIFORMIS* (VON DRASCHE, 1884)<sup>1)</sup>

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Seto Marine Biological Laboratory

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With Text-figures 1-8 and Table 1

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The following six species of the genus *Pyura*, recorded from the Japanese waters; *Cynthia sacciformis* von Drasche, 1884, *Cynthia japonica* Traustedt, 1885, *Cynthia sanderi* Traustedt and Weltner, 1894, *Halocynthia michaelsoni* Oka, 1906, *Pyura aspera* Tokioka, 1949 and *Pyura masuii* Tokioka, 1949, are all very similar to one another. About seventy years ago, Hartmeyer (1906, pp. 4-5) suggested the possibility of the first three species to form a species group (Formenkreis) and regarded the spicule (horn-shaped spicule stated below)-bearing individuals as a special variety in that group. Tokioka (1953, p. 276) placed *P. aspera* and *P. masuii* in the synonymy of *P. sanderi*, regarding the former two as the "young or small" individuals of the latter. He also suggested the identity of *P. sanderi* with *Cynthia michaelsoni* by thinking that the latter might represent an "ecological form" of the former for the harder test, absence of finger-shaped prominences around the apertures and much shallower habitats in the latter. Later Tokioka (1967, pp. 197-8) synonymized *P. sanderi* with *P. sacciformis*. Thus, according to him, only three of the six species, *P. sacciformis*, *P. michaelsoni* and *Cynthia japonica*, are accepted as valid (Tokioka, 1963, p. 140).

As seen in Table 1, some differences are actually discernible between the six described species. However, in order to clarify the taxonomic relations among these species, it is requested to make clear the taxonomic significance of respective criteria adopted in defining them, especially of the test protuberances, the horn-shaped spicules found in various organs, and some others. Fortunately, I had a chance to examine a lot of specimens of this species group from various localities and, after careful observations, came to a conclusion that all the criteria adopted so far might be dropped into the intraspecific variations and therefore of no decisive taxonomic significance, and thus the above-mentioned six species are conspecific and to be united into the same single species: *P. sacciformis*.

Before going further, I would like to express my hearty thanks to Dr. Makoto

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Table 1. Characters of all the described species

Name of described species	Author	Locality (depth)	Size (mm)**	Test consistency and colour
<i>Cynthia sacciformis</i>	Drasche 1884	Japan	ca. 55 mm in diameter	leathery, dark brownish
<i>Cynthia sacciformis</i>	Traustedt 1885	Yokohama	L50, H80, W30	brownish
<i>Cynthia japonica</i>	Traustedt 1885	Japan	L30, H72	thick, firm, somewhat red
<i>Cynthia sanderi</i>	Traustedt & Weltner 1894	Japan	L90, H83	brownish
<i>Halocynthia sanderi</i>	Hartmeyr 1906	Tango (70 m); Tanegawa, Wakayama (30 m); Nagasaki; Misaki; Sagami Bay		
<i>Halocynthia michaelsemi</i>	Oka 1906	Ozika Peninsula	L65, H50	cartilaginous, 4-8 mm thick, reddish grey
<i>Cynthia michaelsemi</i>	Oka 1935	Off Utomari, Mutsu Bay	L68, H90, W40	soft cartilaginous, pale reddish grey
<i>Pyura aspera</i>	Tokioka 1949a	Matoya Bay	L28, H17, W17	*a
<i>Pyura michaelsemi</i>	Tokioka 1949b	Sirahama	L36; L45	
<i>P. michaelsemi</i> var. <i>depressa</i>	Tokioka 1949b	Sugashima	L48, H28, W32	leathery, whitish
<i>Pyura mastui</i>	Tokioka 1949b	Tokyo Bay (bottom)	L30; L35	greyish red
<i>P. sanderi</i>	Tokioka 1953	Sagami Bay (40:60 fms)	L65; L80	cartilaginous, 4-15 mm thick, yellowish white
<i>P. michaelsemi</i>	Tokioka 1954	Osaka Bay	L7-63	*b
<i>P. sacciformis</i>	Tokioka 1967	Off Sunosaki (46-9 fms); Nagasaki	L25; L45	cartilaginous, 4 mm thick, yellowish white
<i>P. sanderi</i>	Rho 1971	East sea of Korea; Korean Strait	L60 (max.)	cartilaginous, yellowish to reddish brown
<i>P. sanderi</i>	Rho 1975	do.	L30-60	
<i>P. sacciformis</i>	Nishikawa MS	Tsukumo Bay, Japan Sea (0 m)	L60, H50	cartilaginous, pinkish or pale reddish brown

- (1) Distribution of the horn-shaped spicules.
  - (2) Number of the branchial folds on each side: (Number of inner longitudinal vessels on respective folds): Number of inner longitudinal vessels in each interspace.
  - (3) Number of genital capsules on the right side: that on the left.
  - (4) Anal margin.
  - (5) Protuberances covering the inner surface of the mantle and other body parts.
  - (6) Siphonal spinules.
  - (7) Well-developed atrial velum.
- \*a "Test cartilaginous, whitish and semitransparent, with a reddish tint around the apertures."
- \*b "The test is cartilaginous (exceptionally it may be leathery) and usually purplish or slightly reddish purple in colour, --. In small individuals, the test is somewhat translucent and pale reddish-purple~milky white with a faint gray-purplish tint."
- \*c "Die beiden sitzen Öffnungen--sind--in der stark gezunzelten und gefalteteten Oberfläche versteckt."
- \*d "The surface is uneven and corrugated, and is partly covered with sand grains and shell fragments on the posterior half. The siphons are especially irregular, being covered with large and small protuberances, which make the positions of the apertures somewhat obscure."

of the species group of *Pyura saciformis* (von Drasche).

Test surface feature	Tentacles	(1)	(2)	(3)	(4)	(5)	(6)	(7)
*c	ca. 30	*g	6					+
	14	*h	6-7					
minutely nodous	9		6					
#small protuberances around apertures	20		6		3-4 lobes			
siphons short	13 larger, with smaller ones		6 (10)9					
*d	13 larger, alternating with smaller ones		6 (20)8-9		plain-margined			
many acute processes around apertures	30		6 (11-18)2	#16:7?	do.	+		+
			6 (13-22)3-6	#18:8?	#do.		+	
smooth	16		6 (12-22)3-5	#20:8?			-	
well-developed protuberances around apertures	16	*i	6 (12-20)3-5			+	-	+
do.	30-40		6 (16-32)2-8	less than 20	plain		+	+
*e			6	14:15				
*f		*j	6 (15-28)2-7	20:6		+		
#protuberances around apertures	19-25		6 (13-34)1-7	#19:4?	plain		+	
	24-32		6 (10-28)3-8	17-19:6-8				
a few small protuberances around apertures	20	*k	6 (22-28)0-12	15:10	two-lobed	+		+

\*e "The surface of smaller individuals is usually smooth, excepting a few small prominences: while the surface is completely wrinkled--in larger individuals, --. Both apertures are sessile and marked each with 8 (4 in younger individuals) lobules. The dorsal ridge uniting both apertures in *P. sanderi* is quite obscure in the present species."

\*f "--dorsal ridge made rather obsolete by finger-shaped protuberances on test surface--"

\*g in the inner wall of mantle and tentacles.

\*h in the tentacles and branchial sac.

\*i "--relatively large ones (tentacles) have a few calcareous spicules in their thickened basal portion."

\*j "--many complicatedly horn-shaped spicules embedded in inner surface layer of mantle, gonad, intestine, ciliated groove, tentacles and most abundantly in larger vessels of branchial sac."

\*k "embedded in the inner surface layer of the ventral region of mantle, gonad, intestine, branchial sac, dorsal tubercle and tentacles, and especially densely in the dorsal tubercle and the wall of heart."

\*\* L--body length, H--height and W--width.

# According to the figures given by the authors.

Tsuchiya of the Asamushi Marine Biological Laboratory of Tôhoku University, Dr. Masaru Ishikawa of Ehime University, Dr. Shin-ichiro Fuse and Mr. Tetsuo Kuwamura of the Seto Marine Biological Laboratory of Kyôto University for their kindness in giving me a chance to examine the specimens from various localities, and also to Dr. Akihiko Inaba and other members of the Mukaishima Marine Biological Laboratory of Hiroshima University, and Dr. Kaname Nikaido and the other member of the Nakashima Marine Biological Laboratory of Ehime University for their courtesy in affording me every facility for availing the laboratories for my studies, further, to all members of and colleagues in the Seto Marine Biological Laboratory for their precious advices. Lastly I note here my gratitude to Dr. Takasi Tokioka, Professor Emeritus of Kyôto University, for his incessant suggestions and advices and his kindness in reading the manuscript.

### Material for the Present Study

In all fifty-nine specimens were gathered from six localities as follows:

Specimens M: 13 specimens from the shore in front of the Mukaishima Mar. Biol. Lab. near Onomichi on the northern coast of the Seto Inland Sea, on May 26, 1975, collected by the author.

Specimen A: A single specimen from the lower intertidal zone at Nishiwaki on Awazishima Island, on Feb. 14, 1975, collected by Fuse.

Specimens G: 8 specimens from the shore at Washi-no-su on Gogozima Island off Matsuyama on the southern coast of the Seto Inland Sea, in June, 1975, collected by Ishikawa and the author.

Specimens N: 3 specimens from the shore of Kyubei-kozima, a small island near the Nakashima Mar. Biol. Lab. on the southern coast of the Seto Inland Sea, on June 11, 1976, collected by the author.

Specimens B: 30 specimens from the sound of Bisan-seto off Kozima on the northern coast of the Seto Inland Sea, 0 to 25 m deep, in 1977, presented by Kuwamura.

Specimens F: 4 specimens from around Futagozima Island in Mutsu Bay, 10 to 20 m deep, collected in Oct., 1977 and reared at the Asamushi Mar. Biol. Lab. till the end of December, 1977 by Tsuchiya.

The four F specimens contained pale brown eggs of about 200  $\mu$  in diameter, but all other specimens were immature or their genital products were wholly shed already.

### Observations

- 1) General features common throughout all the specimens of the present material are:
  - a) More or less marked depression is found around each siphon on the test; this depression is probably related to "the dorsal ridge uniting both apertures" (Tokioka, 1954, p. 91).

- b) White or pale yellow opaque spherules, 150–200  $\mu$  in diameter, are scattered in the superficial layer of the test and tentacles.
  - c) Siphonal spinules are ca. 100  $\mu$  in length (Fig. 1, p).
  - d) A reddish or dark reddish tint is seen on the siphons and the dorsal region of the pale yellowish mantle body.
  - e) Six branchial folds are present on each side; the rudimentary seventh fold may be discernible along the endostyle on each side in larger specimens.
  - f) Parastigmatic vessels are present.
  - g) Atrial velum is well developed.
  - h) Small conical prominences, up to 500  $\mu$  in length are distributed over the inner surface of the mantle and the surface of the intestine and gonads.
  - i) First intestinal loop is narrow.
  - j) Anus is plainly margined.
  - k) There are about 15, and 20 at the maximum, genital capsules on the right, while less than 10 on the left. Respective capsules are flat and square or round in outline on the right; in many specimens, however, the capsules may be expanded to touch one another and may form roughly a large mass in all. On the left, the capsules seemingly form an elongated and more or less cleft mass (Fig. 1, t–x).
- 2) Test protuberances around the apertures.

The appearance of the test protuberances in the treated specimens was classified into five developmental degrees from the type I (indiscernible) to V (well developed) as shown in Fig. 1, a–n, and then the correlation was checked between the developmental degree and the body length (Fig. 2).

This figure seems to show the following points:

- a) Various developmental degrees are seen in the specimens from the same locality, but in four F specimens which are all larger and with protuberances in the type V.
- b) Some positive correlation, though very weak, is seemingly suggestible between the developmental degree and the specimen group, especially M and B specimens.

Generally saying, however, the developmental degrees of the test protuberances are quite continuous from the type I to the type V throughout the whole treated specimens and for the point-a mentioned above the development of the test protuberances may better be regarded as only an intraspecific variation, though it might be correlated somewhat with the growth as roughly suggestible from this figure or as suspected from that the larger F specimens are all furnished with well developed protuberances. Anyhow, the developmental degree of the test protuberances cannot be admitted to be a specific criterion.

Next, in order to see whether or not the development of the test protuberances is affected by the depth of the habitat, the correlation between the developmental degree of the test protuberances and the habitat depth was checked in the largest specimen group B (Fig. 5, left), but no clear correlation was deducible from this figure.

- 3) Horn-shaped spicules (Fig. 1, o).

To see the correlation between the development of the spicules and the growth, the development of the spicules was divided into the following four degrees and the

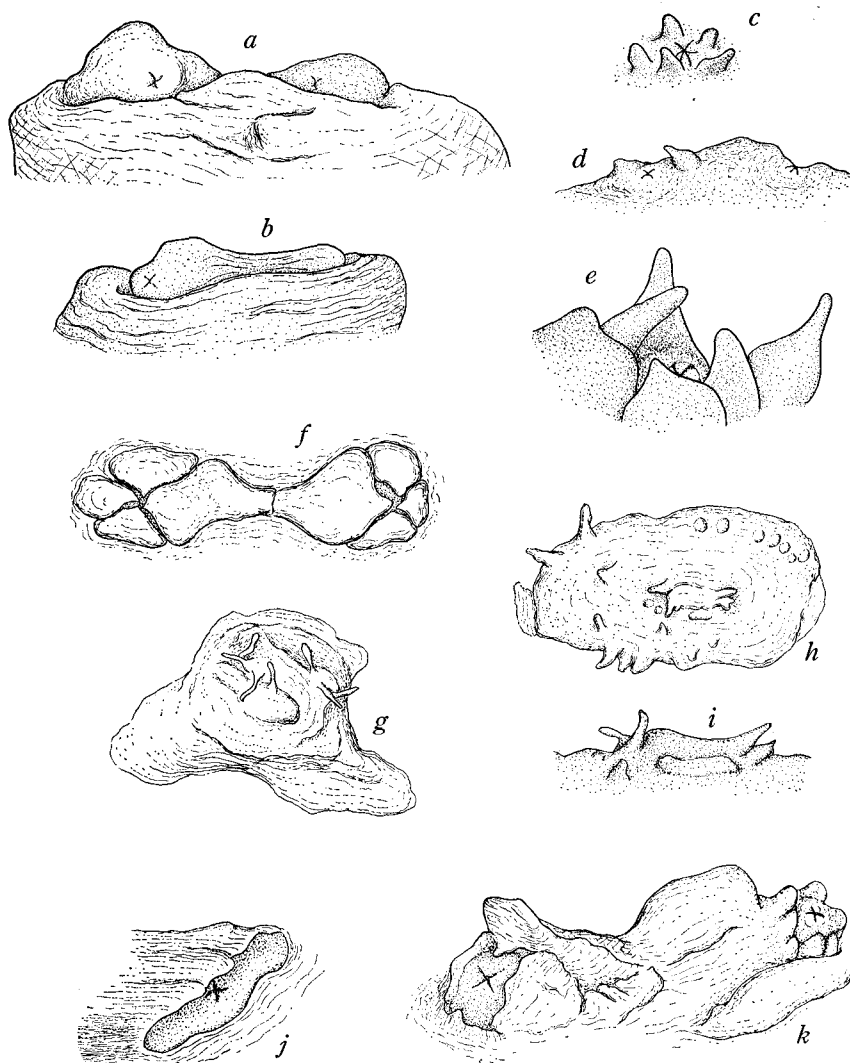


Fig. 1. Development of the test protuberances around the apertures; Degree I (a-b), Degree II (c-d), Degree III (e-i), Degree IV (j) and Degree V (k-n), the horn-shaped spicules, the scale for  $100\mu$  (o), the siphonal spinule, the sac for  $50\mu$  (p), the ciliated groove (q-s), the right gonad (t-w) and the left gonad and part of the intestinal loop (x). a, a 75 mm long individual of G specimen group; b, a 50 mm long specimen of the same group; c, a 30 mm long individual of B specimen group (from 15-20 m deep); d, a 16 mm long individual of B specimen group; e, a 20 mm long individual of M specimen group; f, a 25 mm long individual of the same group; g, a 19 mm long individual of B specimen group (from 13 m deep); h, q and t, a 20 mm long individual of B specimen group (from 25 m deep); i, side aspect of the siphonal region of h; j, a 22 mm long individual of M specimen group; k, a 65 mm long individual of the same group; l, a 75 mm long individual of F specimen group; m, s, w and x, a 93 mm long individual of the same group; n and v, a 80 mm long individual of the same group; r and u, a 73 mm long individual of the same group.

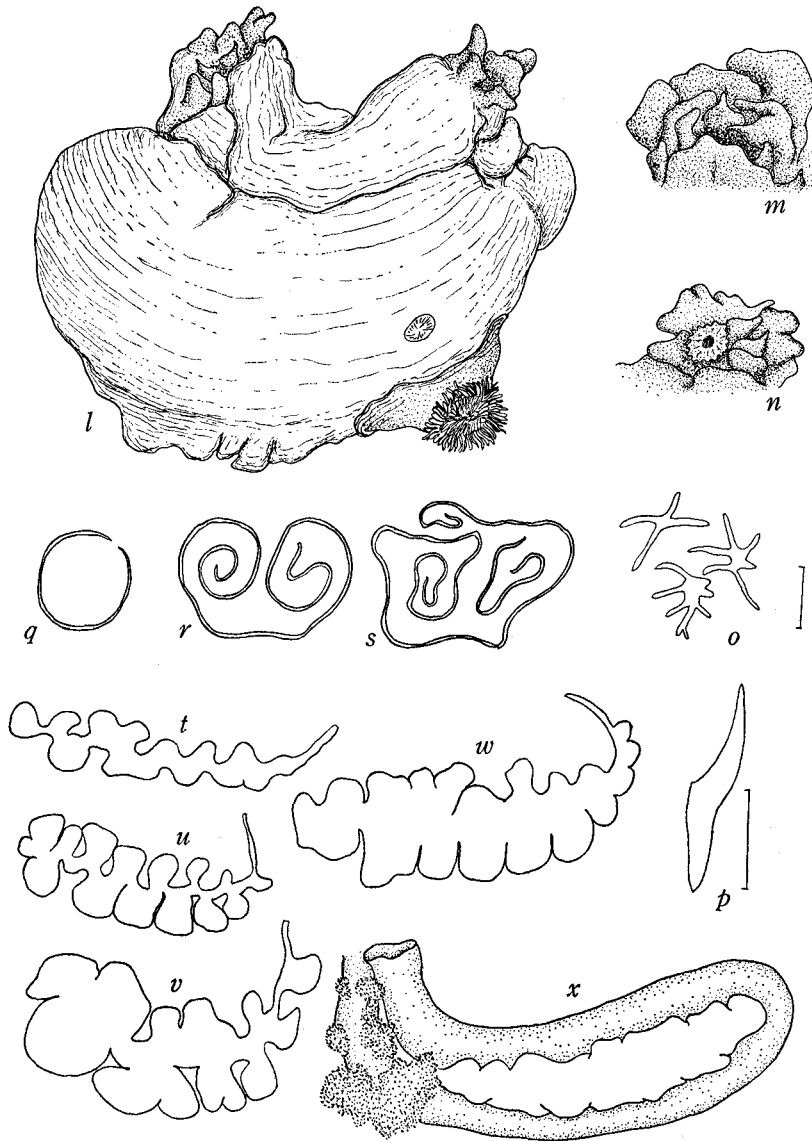


Fig. 1.



correlation was checked between the developmental degree and the body length, as seen in Fig. 3.

- I: No spicules are found.
- II: Spicules are sparsely found in a single organ.
- III: Spicules are found densely in a single organ.
- VI: Spicules are distributed in two or more organs.

From this figure, it seems that no correlation is discernible between the development of the spicules and the body size and that different degrees are defined in the specimens from the same locality, but the F specimens which are all in the state of degree IV as to the development of the spicules. Thus, the developmental degrees of the spicules may probably be attributable to an intraspecific variation and therefore of no taxonomic significance. Further, the correlation between the development of

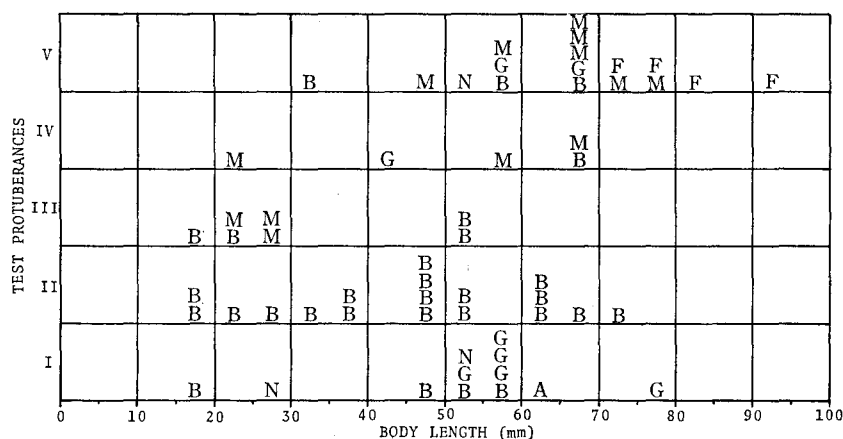


Fig. 2. Correlation between the development (Degrees I to V) of the test protuberances around the apertures and the body length. A, B, F, G, M and N represent respectively an individual of A, B, F, G, M, and N specimen group that are explained in the chapter of material for the present study (p. 82).

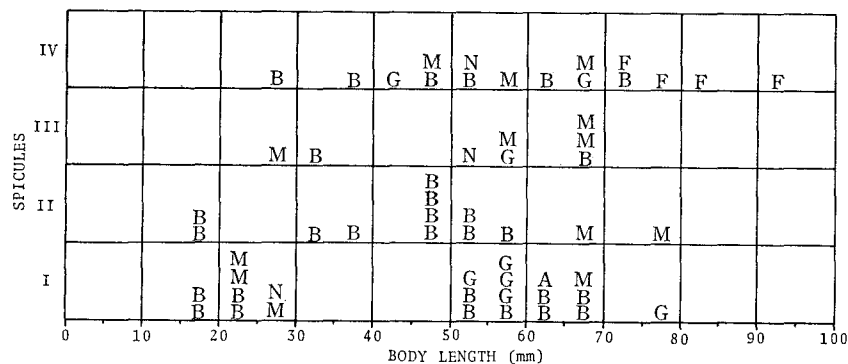


Fig. 3. Correlation between the development (Degrees I to IV) of the horn-shaped spicules and the body length. For A, B, F, G, M, and N, see Fig. 2.

the test protuberances and that of the spicules (Fig. 4) was checked as well as the correlation between the development of the spicules and the depth of the habitats (Fig. 5, right). In both examinations, any clear correlation cannot be discerned. Lastly, the distributions of the spicules in various organs were plotted in Fig. 6, and this revealed that the spicules were, if present, found most frequently in the heart wall and the dorsal tubercle.

The horn-shaped spicules are transparent, colorless, and cannot be dissolved in a solution of hydrochloric acid in contrast with the spicules of *Herdmania momus* (Savigny), that are mineralized with vaterite ( $\text{CaCO}_3$ ) (Lowenstam and Abbott, 1975) and

SPICULES	IV	B	BBBBB		G	FFFF MMM N G
	III	N G			MM	MM BB
	II	BB	B BBBBB	BB		MM B
	I	N G A B	GGGG BB BBBBB	MMM BB	M B	G
		I	II	III	IV	V
		TEST PROTUBERANCES				

Fig. 4. Correlation between the development of the test protuberances and that of the spicules. For A, B, F, G, M, and N, see Fig. 2.

	TEST PROTUBERANCES					SPICULES			
	I	II	III	IV	V	I	II	III	IV
0	B	BBBBB	BB			BBB	BBBBB		
2		BBB			B	BBB		B	
4	B	BB		B		BBB			B
6									
8									
10									
12		B	B				B		B
14					B			B	
16	B	BBBB			B	B	BBBB		B
18	B	B					B		B
20		B							B
22									
24			B			B			
26									

Fig. 5. Correlation between the habitat depth and the development of the test protuberances (left) and the spicules (right) in the specimen group from the sound of Bisan-seto, the Seto Inland Sea. Single B shows an individual.

therefore are dissolvable quickly with the same agent. The exact chemical nature of the horn-shaped spicules is still left unknown.

4) Other characters.

- a) Test consistency and colouration: In smaller specimens, the test is thin, soft, leathery and somewhat translucent, and milky white usually with a pinkish tint in the dorsal region, while in larger ones, it is hard, cartilaginous and generally thick, up to more than 10 mm in thickness (though very thin, in some cases, on the attachment side), and purplish pink or, in lesser cases, pale brownish, as already noted by Tokioka (1954) in *P. michaelsoni*.
- b) Shape of ciliated groove: In smaller specimens, the ciliated groove is simply U-shaped, while in larger ones, it becomes complicated because of the increased wheels in the inrolled horns and of the undulation of the groove itself (Fig. 1, q-s).
- c) Branched protuberances projecting out into the peribranchial cavity from the outer wall of the branchial sac in its anterodorsal region: These protuberances are seemingly more developed in larger specimens, although all the four large F specimens from Mutsu Bay are wholly devoid of or provided with only a few of such protuberances on their branchial sac.
- d) Distributional pattern of the internal longitudinal vessels of the branchial sac: Some branchial formulae are given below for examples.

20 mm long B specimen.

L. D. 2 (16) 2 (14) 2 (18) 1 (18) 1 (15) 2 (11) 2 V.

R. D. 2 (13) 2 (14) 2 (18) 2 (17) 2 (13) 3 (13) 2 V.

55 mm long G specimen.

L. D. 12 (27) 11 (27) 10 (24) 10 (23) 10 (23) 9 (13) 5 V.

R. D. 5 (12) 3 (29) 8 (24) 12 (22) 11 (23) 10 (16) 8 (6) 0 V.

60 mm long A specimen.

L. D. 6 (25) 4 (29) 4 (30) 3 (30) 3 (19) 5 (16) 1 (2) 0 V.

R. D. 8 (24) 3 (29) 2 (29) 4 (27) 4 (22) 4 (17) 3 (4) 0 V.

Heart	+			++	+	+	++	+	+	+	++	+	++	++	++	++
Mantle wall								+			+	+		+	+	+
Dorsal tubercle			+		+					+		+	+	+	++	++
Branchial sac									+		+		+	+	+	+
Tentacles												+				++
Stomach		+												+	+	+
Intestine						+			+					+	++	+
Gonad							+			+			+	+	+	+
Number of individuals provided with spicules in respective specimen group	M	1		1	4	3										
	A															
	G		1			2										
	N				1		1									
	B	11			2			1	1	1	1		1	1		
	F											1			1	1

Fig. 6. Distribution of the horn-shaped spicules in various organs. ++: dense distribution. A, B, F, G, M and N: specimen groups (see p. 82).

80 mm long specimen.

L. D. 12 (27) 4 (30) 3 (28) 4 (27) 6 (24) 7 (19) 5 (5) 0 V.

R. D. 11 (28) 3 (30) 4 (32) 5 (28) 8 (26) 5 (24) 6 (4) 0 V.

It may be said safely that the number of the internal longitudinal vessels on respective folds increases with the body length.

- e) The number of the tentacles fluctuates usually in the range from 20 to 30, inclusive of minute ones. They are branched in two or three orders.

### Consideration and Conclusion

The characteristics defining the six described species shown in Table 1 are all clearly involved within the range of variation as to respective characters checked above.

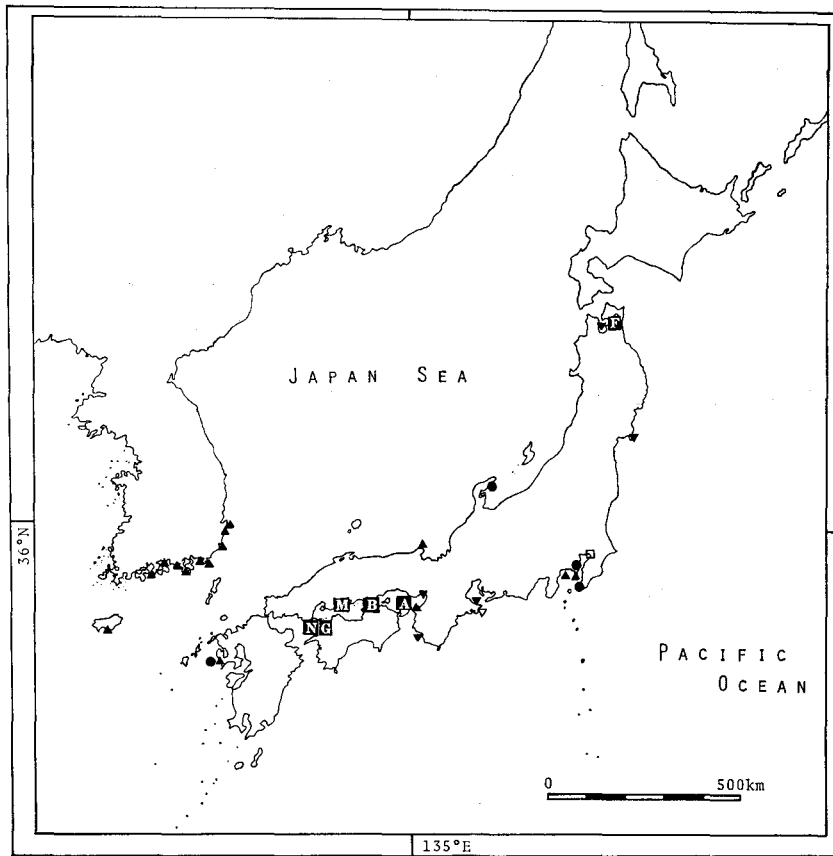


Fig. 7. Geographical distribution of *Pyura saciformis* (von Drasche). Solid square: localities of the specimens treated in the present paper; for A, B, F, G, M and N see p. 000. Solid circle: localities of the specimens so far described under the specific name *saciformis*. Solid triangle: localities of the specimens described as *sanderi*. Inverted solid triangle: of those described as *michaelseni*. Inverted open triangle: of the specimen described as *aspera*. Open square: of the specimen described as *masuii*. (Only the specifiable localities are shown; for full localities, see Table 1).

Only the internal longitudinal vessels of the branchial sac are seemingly less in *Cynthia japonica* and *Halocynthia michaelsoni* even in larger specimens. Thus it seems more reasonable to unify the six described species in question altogether into the single species that should have the specific name of *Pyura sacciformis* according to the law of priority rather than to admit all or some of them as valid as species. However, the present conclusion will never reject the subdivision of this species into some taxa below the rank of the species, as such subdivision might be suspected from, for instance, that some positive weak correlation is perceivable between the developmental degree of the test protuberances and some specimen groups (M and B, see p. 83) and that the internal longitudinal vessels of the branchial sac rather less even in larger specimens in *Cynthia japonica* and *Halocynthia michaelsoni*. Further examinations especially on the specimens from northern Japan and Korean coasts and closer researches on the embryology to larval development in the specimens from different habitats and localities are needed to make clear the taxonomic significance of further subdivision of the species.

The full synonymy of the species is given as follows:

*Pyura sacciformis* (von Drasche, 1884)

(Japanese-name: Mihaeru-boya Oka, 1927)

*Cynthia sacciformis*—von Drasche, 1884, p. 376, pl. 5, figs. 2–3; Traustedt, 1885, pp. 32–33, pl. 4, figs. 34–35.

*Pyura sacciformis*—Tokioka, 1967, pp. 197–198, fig. 86.

*Cynthia japonica*—Traustedt, 1885, pp. 30–31, p. 54, pl. 4, fig. 38.

*Cynthia sanderi*—Traustedt and Weltner, 1894, pp. 11–12, pl. 2, figs. 1–3.

*Halocynthia sanderi*—Hartmayer, 1906, pp. 4–5.

*Halocynthia michaelsoni*—Oka, 1906, pp. 46–47.

*Cynthia michaelsoni*—Oka, 1935, pp. 437–439, fig. 7.

*Pyura aspera*—Tokioka, 1949a, pp. 10–11, pl. 4, figs. 6–8.

*Pyura michaelsoni*—Tokioka, 1949b, pp. 54–55, pl. 8, fig. 3, text-fig. 10; 1954, pp. 90–91, pl. 7, figs. 22–25.

*Pyura michaelsoni* var. *depressa*—Tokioka, 1949b, pp. 56–57, pl. 8, fig. 4, text-fig. 11.

*Pyura masuii*—Tokioka, 1949b, pp. 57–58, text-fig. 12.

*Pyura sanderi*—Tokioka, 1953, pp. 275–276, pl. 67, figs. 1–9, pl. 68, figs. 1–2; Rho, 1971, pp. 122–123, pl. 8, figs. 1–4; 1975, pp. 144–145.

*Geographical distribution:* See in Fig. 7.

*Related species:* *Pyura stolonifera* (Heller, 1878) *stolonifera* (Heller, 1878) from South Africa is very similar to *P. sacciformis* especially in the occasional appearance of the test protuberances around the apertures, the sunken area around siphons, horn-shaped spicules in various organs except in the test, pointed papillae on the inner surface of mantle, and in the feature of gonad, the narrow intestinal loop and 6 or 7 branchial folds (see Kott, 1976, pp. 82–4; Millar, 1955, p. 210 etc.). This subspecies lives “in dense beds in the sublittoral fringe (low tide to about 10 metres depth) of exposed rocky shores” (Griffiths, 1976, p. 1, also see Day, 1970), while *P. sacciformis* seems to live in rather protected areas and in wider range of depth. As the larval development

of *Pyura stolonifera stolonifera* has already been examined by Griffiths (1976), it is desirable that the same examination is made on the development in the specimens of different features in *P. sacciformis* to reveal the exact affinity between them.

*Pyura violacea* Pérès, 1949, from Senegal, Mauritania and Morocco in West Africa, which is "possibly conspecific with *P. stolonifera*" (Millar, 1967, p. 203, also Pérès, 1951, pp. 1061–2), is also similar to *P. sacciformis* in having the test protuberances around the apertures, a violet tint of the test, six branchial folds on each side and the horn-shaped spicules, but the pattern of colouration of the test seems quite different between the two.

In addition to the two species mentioned above, there are four more species which are provided with horn-shaped spicules; they are 1. *P. hystrix* (Oka, 1930) from about 200 m deep in Sagami Bay, Japan, 2. *P. spinifera* (Quoy and Gaimard, 1834) from West Australia, 3. *P. antillarum* Van Name, 1921 from the 496 fathoms deep in West Indies, and 4. *P. bradleyi* Van Name, 1931 from Peru and Ecuador. All these are, however, distinguishable from *P. sacciformis* by the body shape (3, 4), the external feature of the test (1, 2, 3, 4), the structure of the gonad (1, 3, 4), and some other natures, though all the four species are provided with 6 or 7 branchial folds on each side as *P. sacciformis*. PS. After the manuscript was sent to the editorial board of the journal, it was found that a very important record was overlooked. This record is included in the following paper: Kott, P. (1964) Stolidobranch and phlebobranch ascidians of the Queensland coast. Pap. Dept. Zool. Univ. Qd., 2(7), pp. 127–152, 10 figs. and 2 tables. There is described a single specimen of *Pyura michaelsoni* (Oka) from Heron Is., Barrier reef (pp. 140–141 and fig. 7), in which "...red pigment present on upper surface and in siphon, 1 cm long. Both apertures on upper surface and surrounded by large promi-

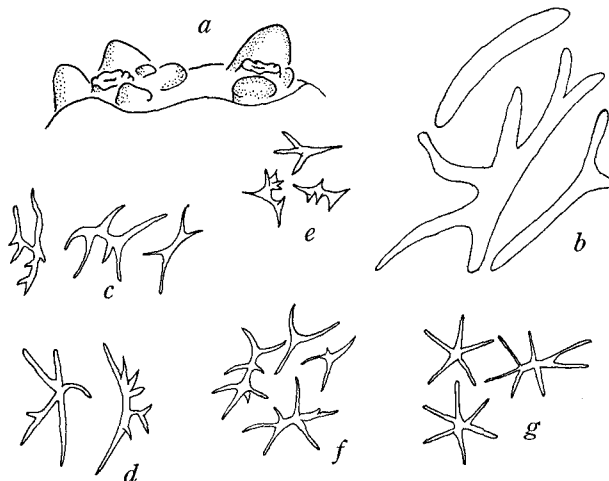


Fig. 8. Test protuberances around the apertures (a) in *Pyura stolonifera stolonifera* (Heller) (from Millar, 1955), and horn-shaped spicules from various organs in (b) *P. stolonifera stolonifera* (Heller) (from Millar, 1962), (c) *P. violacea* Pérès (Pérès, 1949), (d) *P. hystrix* (Oka) (from Oka, 1930), (e) *P. spinifera* (Quoy and Gaimard) (from Kott, 1972b), (f) *P. antillarum* Van Name (from Van Name, 1945) and (g) *P. bradleyi* Van Name (from Van Name, 1945).

nences of thickened test material so that they appear to open into depressed pits. These prominences...particularly well developed between openings and curve over protecting them. Finger-like lobes present around openings. Siphonal spines identical with those previously described for species....Six folds in branchial sac on each side of body. Longitudinal vessels arranged according to following formula: E2 (6) 3 (10) 2 (11) 2 (8) 1 (10) 2 (8) DL...". Kott considers that "the dorsal thickening of the test around the apertures is particularly distinctive and related to the condition also found in *Pyura sanderi* (described by) Tokioka...".

According to the present author's review given in this paper, this must be the first record of *P. sacciformis* outside the Japanese and adjacent waters, though it is not impossible that this Australian specimen might be a specimen of *P. stolonifera stolonifera*, ever recorded from South Africa and very similar to *P. sacciformis* (see *Related species* in the text), or an aberrant individual of *P. stolonifera praeputialis* Heller recorded from Australia, which is distinguishable from *P. stolonifera stolonifera* only by the absence of test projections in the siphonal region and the difference in locality (see Kott, 1976, pp. 82-84).

#### LITERATURE

- Day, J. H. 1970. The biology of False Bay, South Africa. Trans. Roy. Soc. South Africa, 39: 211-221, 1 tab., 1 fig.
- Drasche, R. von. 1884. Ueber einige neue und weniger bekannte ausser-europäische einfache Ascidien. Denkschr. Akad. Wiss. Wien, 48: 369-386, pls. 1-8.
- Griffiths, R. J. 1976. The larval development of *Pyura stolonifera* (Tunicata). Trans. Roy. Soc. South Africa, 42: 1-9, 3 tabs., 5 figs.
- Hartmeyer, R. 1906. Ein beitrage zur Kenntnis der japanischen Ascidienfauna. Zool. Anz., 31: 1-30, 12 figs.
- Kott, P. 1952. The ascidians of Australia. I. Stolidobranchiata Lahille and Phlebobranchiata Lahille. Aust. J. Mar. Freshwater Res., 3: 205-335, 183 figs.
- 1972a. The ascidians of South Australia I: Spencer Gulf, St. Vincent Gulf and Encounter Bay. Trans. Roy. Soc. South Australia, 96: 1-52, 1 tab., 68 figs.
- 1972b. The ascidians of South Australia II: Investigator Strait, and the eastern end of the Great Australian Bight. Ibid., 96: 165-196, 60 figs.
- 1975. The ascidians of South Australia III: Northern sector of the Great Australian Bight and additional records. Ibid., 99: 1-20.
- 1976. The ascidian fauna of Western Port, Victoria, and a comparison with that of Port Phillip Bay. Mem. Nat. Mus. Victoria, 37: 53-95, 1 tab., 1 map, 48 figs.
- Lowenstam, H.A. and Abbott, D.P. 1975. Vaterite: a mineralization product of the hard tissues of a marine organism (Ascidacea). Science, 188: 363-365, 2 figs.
- Millar, R. H. 1955. On a collection of ascidians from South Africa. Proc. Zool. Soc. Lond., 125: 169-221, 40 figs.
- 1960. Ascidacea. Discovery Report, 30: 1-160, 6 pls., 72 figs.
- 1962. Further descriptions of South African ascidians. Ann. South Africa Mus., 46: 113-221, 3 tabs., 45 figs.
- 1963. Australian ascidians in the British Museum (Natural History). Proc. Zool. Soc. Lond., 141: 689-746, 47 figs.
- 1966. Ascidacea. Port Phillip Survey. Mem. Nat. Mus. Victoria, 27: 357-375, 11 figs.
- 1967. Ascidians of Rabat, Morocco. Bull. Soc. Sci. nat. phys. Maroc, 47, 1er et 2e trimestres: 201-206, 3 figs.

- Oka, A. 1906. Notizen über japonische Ascidien I. Annot. Zool. Japan., 6: 37-52.
- 1930. Ueber eine merkwürdige Cynthiide aus der Bucht von Sagami. Proc. Imp. Acad., 6: 317-320, 4 figs.
- 1935. Report of the biological survey of Mutsu Bay 28. Ascidiae simplices. Sci. Rep. Tōhoku Imp. Univ., 10: 427-466, 34 figs.
- Pérès, L.M. 1949. Contribution a l'étude des ascidies de la côte occidentale d'Afrique. Bull. Inst. franç. Afr., noire, 11: 159-207, 27 figs.
- 1951. Nouvelle contribution a l'étude des ascidies de la côte occidentale d'Afrique. Ibid., 13: 1051-1071, 10 figs.
- Rho, B. J. 1971. A study on the classification and the distribution of the Korean ascidians. Jour. Kor. Res. Inst. Bet. Liv., 6: 103-160, 5 tabs., 13 pls., 2 figs.
- 1975. On the classification and the distribution of the marine benthic animals in Korea 3. Ascidians. Ibid., 15: 121-169, 11 pls., 1 fig.
- Sluiter, C.P. 1927. Les ascidies de la cote atlantique du Maroc. Bull. Soc. Sci. Nat. Maroc, 1927: 50-99, 2 pls., 11 figs.
- Tokioka, T. 1949a. Contributions to the Japanese ascidian fauna. I. Ascidians collected by Prof. Miyadi and Mr. Masui during the bottom survey 1939-40. Publ. Seto Mar. Biol. Lab., 1: 1-17, 7 pls.
- 1949b. Contributions to the Japanese ascidian fauna II. Notes on some ascidians collected chiefly along the coast of Kii Peninsula. Ibid., 1: 39-64, 1 pl., 16 figs.
- 1953. Ascidians of Sagami Bay. Tokyo, 515 pp., 80 pls., 25 figs.
- 1954. Contributions to the Japanese ascidian fauna X. Notes on some ascidians collected in Ōsaka Bay (2). Publ. Seto Mar. Biol. Lab., 4: 75-98, 5 pls., 7 figs.
- 1963. Contributions to the Japanese ascidian fauna XX. The outline of Japanese ascidian fauna as compared with that of the Pacific coasts of North America. Ibid., 11: 131-156.
- 1967. Pacific Tunicata of the United States National Museum. U.S. National Mus. Bull., 100, 247 pp., 105 figs.
- Traustedt, M.P.A. 1885. Ascidia simplices fra det Stille Ocean. Vidensk. Meddel. fra den naturh. Foren., ann. 1884: 1-60, 4 pls.
- Traustedt, M.P.A. and Weltner, W. 1894. Bericht über die von Herrn Dr. Sander gesammelten Tunicaten. Arch. Naturg., 60: 10-14, 1 pl.
- Van Name, W.G. 1945. The North and South American ascidians. Bull. Amer. Mus. Nat. Hist., 84: 1-476, 31 pls., 327 figs.